

Claims

What is claimed is:

1. A method of forming a complement image of a master, comprising the steps of:
 - 5 a) providing a master that comprises a first set of molecules bound to a first substrate to form a pattern;
 - b) assembling via attractive forces or bond formation a second set of molecules on the first set of molecules, wherein each molecule in the second set of molecules comprises:
 - 10 i) a reactive functional group; and
 - ii) a recognition component that is attracted to or binds to one or more of the first set of molecules;
 - c) contacting the reactive functional group of the second set of molecules with a surface of a second substrate, thereby forming a bond between the second set of molecules and the second substrate;
 - 15 d) breaking the attractive force or bonds between the first set of molecules and the second set of molecules, thereby forming a complement image of the master; and
 - e) optionally repeating steps b) through d) one or more times.
- 20 2. The method of Claim 1, wherein each molecule of the second set of molecules further comprises one or more of the following components:
 - a) an exposed functionality;
 - b) a covalent bond or a first spacer that links the reactive functional group to the recognition component; and
 - 25 c) a covalent bond or a second spacer that links the exposed functionality to the recognition component.

3. The method of Claim 2, wherein the second set of molecules is assembled on the first set of molecules by contacting the master with a solution comprising the second set of molecules.
- 5 4. The method of Claim 3, wherein the master is held in contact with the second substrate by capillary action of the solution containing the second set of molecules.
5. The method of Claim 4, wherein the solution is evaporated.
- 10 6. The method of Claim 3, wherein the second set of molecules comprises two or more different molecules.
- 15 7. The method of Claim 6, wherein one or more molecules from the first set of molecules determines where each of the molecules from the second set of molecules binds.
8. The method of Claim 7, wherein two or more molecules of the second set of molecules have different recognition components.
- 20 9. The method of Claim 7, wherein two or more molecules of the second set of molecules have both different recognition components and different exposed functionalities.
- 25 10. The method of Claim 7, wherein the two or more different molecules of the second set of molecules form a pattern on the second substrate that has a height profile that comprises two or more depths.

11. The method of Claim 10, wherein at least one of the two or more different molecules comprises a first spacer, and another of the two or more different molecules either does not comprise a spacer or comprises a second spacer that has a different length from the first spacer.
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12. The method of Claim 2, wherein a lateral dimension of at least one feature of the complement image is less than 200 nm.
13. The method of Claim 2, wherein the bonds formed between the first set of molecules and the second set of molecules are hydrogen bonds, ionic bonds, covalent bonds, van der Waals bonds, or a combination thereof.
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14. The method of Claim 13, wherein the bonds between the first set of molecules and the second set of molecules are broken by applying heat.
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15. The method of Claim 13, wherein the bonds formed between the first set of molecules and the second set of molecules are hydrogen bonds.
16. The method of Claim 15, wherein the bonds between the first set of molecules and the second set of molecules are broken by contacting the bonds with a solution having a high ionic strength.
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17. The method of Claim 2, wherein the reactive functional group on the second set of molecules is a thiol group or a protected thiol group, and the surface of the second substrate is gold, silver, copper, cadmium, zinc, palladium, platinum, mercury, lead, iron, chromium, manganese, tungsten, or any alloys thereof.
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18. The method of Claim 2, wherein the reactive functional group on the second set of molecules is a silane or a chlorosilane, and the surface of the second substrate is doped or undoped silicon.
- 5 19. The method of Claim 2, wherein the reactive functional group on the second set of molecules is a carboxylic acid, and the surface of the second substrate is an oxide.
20. The method of Claim 19, wherein the oxide is silica, alumina, quartz, or glass.
- 10 21. The method of Claim 2, wherein the reactive functional group on the second set of molecules is a nitrile or an isonitrile, and the surface of the second substrate is platinum, palladium or any alloy thereof.
- 15 22. The method of Claim 2, wherein the reactive functional group on the second set of molecules is a hydroxamic acid, and the surface of the second substrate is copper.
- 20 23. The method of Claim 2, wherein a component of each of the first set of molecules is a nucleic acid sequence and the recognition component of the second set of molecules is a nucleic acid sequence that has at least three consecutive bases that are complementary to at least three consecutive bases of at least one molecule from the first set of molecules.
- 25 24. The method of Claim 23, wherein the bonds formed between the first set of molecules and the second set of molecules are hydrogen bonds.
25. The method of Claim 24, wherein the second set of molecules comprises two or more different molecules.

26. The method of Claim 25, wherein one or more molecules from the first set of molecules determines where each of the molecules from the second set of molecules binds.
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27. The method of Claim 26, wherein the first set of molecules comprises two or more molecules having different nucleic acid sequences.
28. The method of Claim 26, wherein two or more molecules of the second set of molecules have different nucleic acid sequences.
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29. The method of Claim 24, wherein the hydrogen bonds between the first set of molecules and the second set of molecules are broken by applying heat.
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30. The method of Claim 24, wherein the hydrogen bonds between the first set of molecules and the second set of molecules are broken by contacting the bonds with an enzyme.
31. The method of Claim 24, wherein the hydrogen bonds between the first set of molecules and the second set of molecules are broken by contacting the bonds with a solution having a high ionic strength.
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32. The method of Claim 23, wherein the nucleic acid sequence of the first and second sets of molecules are selected from the group consisting of DNA, RNA, modified nucleic acid sequences and combinations thereof.
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33. The method of Claim 2, wherein a component of each of the first set of molecules is a peptide nucleic acid (PNA) sequence and the recognition component of the second set of molecules is a PNA sequence.

34. The method of Claim 2, wherein the exposed functionality of each molecule of the second set of molecules is absent or is, independently, selected from the group consisting of -OH, -CONH-, -CONHCO-, -NH₂, -NH-, -COOH, -COOR, -CSNH-, -NO₂⁻, -SO₂, -SH, -RCOR-, -RCSR-, -RSR, -ROR-, -PO₄⁻³, -OSO₃⁻², -SO₃⁻, -COO⁻, -SOO⁻, -RSOR-, -CONR₂, -(OCH₂CH₂)_nOH (where n=1-20, preferably 1-8), -CH₃, -PO₃H⁻, -2-imidazole, -N(CH₃)₂, -NR₂, -PO₃H₂, -CN, -(CF₂)_nCF₃ (where n=1-20, preferably 1-8), and an olefin, wherein, R is hydrogen, a hydrocarbon, a halogenated hydrocarbon, a protein, an enzyme, a carbohydrates, a lectin, a hormone, a receptor, an antigen, an antibody, or a hapten.
35. The method of Claim 34, further comprising the step of binding the exposed functional group of at least one of the second set of molecules to a metal or a metal ion.
36. The method of Claim 35, wherein the exposed functional group is -SH, and the metal or metal ion is Au⁰, Ag⁰, or Ag⁺.
37. The method of Claim 35, wherein the exposed functional group is -COOH, and the metal or metal ion is Ag⁰ or Ag⁺.
38. The method of Claim 2, wherein the second set of molecules has a first spacer, a second spacer, or a first and the second spacer, and the spacers are, independently, selected from the group consisting of an alkylene, a heteroalkylene, a heterocycloalkylene, an alkenylene, an alkynylene, an arylene, a heteroarylene, arylalkylene, and a heteroarylalkylene, wherein the alkylene, heteroalkylene, heterocycloalkylene, alkenylene, alkynylene, arylene, heteroarylene, arylalkylene, or heteroarylalkylene may be substituted or unsubstituted.

39. The method of Claim 38, wherein the substituents for the alkylene, a heteroalkylene, a heterocycloalkylene, an alkenylene, an alkynylene, an arylene, a heteroarylene, an arylalkylene, and a heteroarylalkylene are selected from the group consisting of halogens and hydroxy.
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40. The method of Claim 2, further comprising the steps of:
- a) forming a pattern of one or more metal, metal oxide, or combinations thereof on a surface of a substrate using electron beam lithography;
- 10 b) contacting the surface with the first set of molecules, wherein each molecule of the first set of molecules has a reactive functional group that forms a bond between the metal or metal oxide and the molecules of the first set of molecules, thereby forming a master that comprises a first set of molecules bound to the substrate to form a pattern.
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41. The method of Claim 40, wherein the reactive functional group of at least one molecule from the first set of molecules is a thiol group or a protected thiol group, and at least a portion of the pattern formed is a metal selected from the group consisting of gold, silver, copper, cadmium, zinc, palladium, platinum, mercury, lead, iron, chromium, manganese, tungsten, and any alloys thereof.
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42. The method of Claim 40, wherein the reactive functional group of at least one molecule from the first set of molecules is a silane or a chlorosilane, and at least a portion of the pattern formed is a metal selected from the group consisting of doped and undoped silicon.
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43. The method of Claim 40, wherein the reactive functional group of at least one molecule from the first set of molecules is a carboxylic acid, and at least a portion

of the pattern formed is an oxide selected from the group consisting of silica, alumina, quartz, and glass.

- 5 44. The method of Claim 40, wherein the reactive functional group of at least one molecule from the first set of molecules is a nitrile or an isonitrile, and at least a portion of the pattern formed is a metal selected from the group consisting of platinum, palladium and alloys thereof.
- 10 45. The method of Claim 40, wherein the reactive functional group of at least one molecule from the first set of molecules is a hydroxamic acid, and at least a portion of the pattern formed is copper.
- 15 46. The method of Claim 2, wherein the step of providing the master comprises forming the master using dip pen nanolithography.
47. The method of Claim 2, wherein the step of providing the master comprises forming the master using replacement lithography, nanoshading or nanografting.
- 20 48. The method of Claim 2, wherein the step of providing the master comprises forming the master using nanopatterning.
49. The method of Claim 2, wherein at least one portion of the second substrate surface is free of the second set of molecules.
- 25 50. The method of Claim 49, further comprising the steps of:
a) contacting the surface of the second substrate with a reactant selected to be chemically inert to the second set of molecules and to degrade at least the surface layer of the second substrate, thereby degrading the portion of the

surface of the second substrate that is free of the second set of molecules;
and

- b) removing the second set of molecules to uncover a portion of the surface of the second substrate.

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51. The method of Claim 50, wherein the reactant is a reactive ion etching compound.

52. The method of Claim 49, further comprising the steps of:

- a) depositing a material on the portion of the second substrate surface that is
10 free of the second set of molecules; and
- b) removing the second set of molecules to uncover a portion of the surface of the second substrate.

15 53. The method of Claim 52, wherein the deposited material is selected from the group consisting of semiconductors, dielectrics, metals, metal oxides, metal nitrides, metal carbides, and combinations thereof.

54. The method of Claim 2, wherein the second set of molecules are assembled on the first set of molecules via attractive forces that are magnetic forces.

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55. The method of Claim 54, wherein the attractive forces between the first set of molecules and the second set of molecules are broken by applying a magnetic field.

25 56. The method of Claim 54, wherein the recognition component of one or more molecules in the second set of molecules is an iron or iron oxide particle.

57. A method of forming a reproduction of a master, or portion thereof, comprising the steps of:

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- a) providing a master that comprises a first set of molecules bound to a first substrate to form a pattern;
- b) assembling via bond formation a second set of molecules on the first set of molecules, wherein each molecule in the second set of molecules comprises:
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- i) a reactive functional group; and
- ii) a recognition component that binds to the first set of molecules;
- c) contacting the reactive functional group of the second set of molecules with a surface of a second substrate, thereby forming a bond between the second set of molecules and the second substrate;
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- d) breaking the bonds between the first set of molecules and the second set of molecules, thereby forming a complement image of the master;
- e) assembling via bond formation a third set of molecules on the second set of molecules of the complement image, wherein each molecule in the third set of molecules comprises:
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- i) a reactive functional group; and
- ii) a recognition component that binds to the second set of molecules;
- f) contacting the reactive functional group of the third set of molecules with a surface of a third substrate, thereby forming a bond between the third set of molecules and the third substrate;
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- g) breaking the bonds between the second set of molecules and the third set of molecules, thereby forming the reproduction of the master, or portion thereof; and
- h) optionally repeating steps e) through g) one or more times.

58. The method of Claim 57, wherein each molecule of the second set of molecules optionally further comprises a spacer that links the reactive functional group to the recognition component and each molecule of the third set of molecules further comprises one or more of the following components:

- a) an exposed functionality;
 - b) a covalent bond or a first spacer that links the reactive functional group to the recognition component; and
 - c) a covalent bond or a second spacer that links the exposed functionality to the recognition component.
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59. The method of Claim 58, wherein the third set of molecules is assembled on the second set of molecules by contacting the complement image with a solution comprising the third set of molecules.

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60. The method of Claim 59, wherein the complement image is held in contact with the third substrate by capillary action of the solution containing the third set of molecules.

15 61. The method of Claim 60, wherein the solution is evaporated.

62. The method of Claim 58, wherein the third set of molecules comprises two or more different molecules.

20 63. The method of Claim 62, wherein one or more molecules from the first set of molecules determines where each of the molecules from the second set of molecules binds, and one or more molecules from the second set of molecules determines where each of the molecules from the third set of molecules binds.

25 64. The method of Claim 63, wherein two or more molecules of the third set of molecules have different recognition components.

65. The method of Claim 63, wherein two or more molecules of the third set of molecules have both different recognition components and different exposed functionalities.
- 5 66. The method of Claim 63, wherein the two or more different molecules of the third set of molecules form a pattern on the third substrate that has a height profile that comprises two or more depths.
- 10 67. The method of Claim 66, wherein at least one of the two or more different molecules comprises a first spacer, and another of the two or more different molecules either does not comprise a spacer or comprises a second spacer that has a different length from the first spacer.
- 15 68. The method of Claim 58, wherein a lateral dimension of at least one feature of the reproduction, or portion thereof, of the master is less than 200 nm.
- 20 69. The method of Claim 58, wherein the bonds formed between the second set of molecules and the third set of molecules are hydrogen bonds, ionic bonds, covalent bonds, van der Waals bonds, or a combination thereof.
70. The method of Claim 69, wherein the bonds between the second set of molecules and the third set of molecules are broken by applying heat.
- 25 71. The method of Claim 69, wherein the bonds formed between the second set of molecules and the third set of molecules are hydrogen bonds.
72. The method of Claim 71, wherein the bonds between the second set of molecules and the third set of molecules are broken by contacting the bonds with a solution having a high ionic strength.

73. The method of Claim 58, wherein the reactive functional group on the third set of molecules is a thiol group or a protected thiol group, and the surface of the third substrate is gold, silver, copper, cadmium, zinc, palladium, platinum, mercury, lead, iron, chromium, manganese, tungsten, or any alloys thereof.
74. The method of Claim 58, wherein the reactive functional group on the third set of molecules is a silane or a chlorosilane, and the surface of the third substrate is doped or undoped silicon.
75. The method of Claim 58, wherein the reactive functional group on the third set of molecules is a carboxylic acid, and the surface of the third substrate is an oxide.
76. The method of Claim 75, wherein the oxide is silica, alumina, quartz, or glass.
77. The method of Claim 58, wherein the reactive functional group on the third set of molecules is a nitrile or an isonitrile, and the surface of the third substrate is platinum, palladium or any alloy thereof.
78. The method of Claim 58, wherein the reactive functional group on the third set of molecules is a hydroxamic acid, and the surface of the third substrate is copper.
79. The method of Claim 58, wherein a component of each of the second set of molecules is a nucleic acid sequence and the recognition component of the third set of molecules is a nucleic acid sequence that has at least three consecutive bases that are complementary to at least three consecutive bases of at least one molecule from the second set of molecules.

80. The method of Claim 79, wherein the bonds formed between the second set of molecules and the third set of molecules are hydrogen bonds.
- 5 81. The method of Claim 80, wherein the third set of molecules comprises two or more different molecules.
- 10 82. The method of Claim 81, wherein one or more molecules from the first set of molecules determines where each of the molecules from the second set of molecules binds, and one or more molecules from the second set of molecules determines where each of the molecules from the third set of molecules binds.
83. The method of Claim 82, wherein the second set of molecules comprises two or more molecules having different nucleic acid sequences.
- 15 84. The method of Claim 82, wherein two or more molecules of the third set of molecules have different nucleic acid sequences.
- 20 85. The method of Claim 80, wherein the hydrogen bonds between the second set of molecules and the third set of molecules are broken by applying heat.
86. The method of Claim 80, wherein the hydrogen bonds between the second set of molecules and the third set of molecules are broken by contacting the bonds with an enzyme.
- 25 87. The method of Claim 80, wherein the hydrogen bonds between the second set of molecules and the third set of molecules are broken by contacting the bonds with a solution having a high ionic strength.

88. The method of Claim 79, wherein a component of one or more molecules of the first set of molecules is a nucleic acid sequence.
89. The method of Claim 88, wherein the nucleic acid sequence of the first, second and third sets of molecules are selected from the group consisting of DNA, RNA, modified nucleic acid sequences and combinations thereof.
90. The method of Claim 58, wherein a component of each of the first set of molecules is a peptide nucleic acid (PNA) sequence and the recognition component of the first and second set of molecules is a PNA sequence.
91. The method of Claim 58, wherein the exposed functionality of each molecule of the third set of molecules is absent or is, independently, selected from the group consisting of -OH, -CONH-, -CONHCO-, -NH₂, -NH-, -COOH, -COOR, -CSNH-, -NO₂⁻, -SO₂, -SH, -RCOR-, -RCSR-, -RSR, -ROR-, -PO₄⁻³, -OSO₃⁻², -SO₃⁻, -COO⁻, -SOO⁻, -RSOR-, -CONR₂, -(OCH₂CH₂)_nOH (where n=1-20, preferably 1-8), -CH₃, -PO₃H⁻, -2-imidazole, -N(CH₃)₂, -NR₂, -PO₃H₂, -CN, -(CF₂)_nCF₃ (where n=1-20, preferably 1-8), and an olefin, wherein, R is hydrogen, a hydrocarbon, a halogenated hydrocarbon, a protein, an enzyme, a carbohydrates, a lectin, a hormone, a receptor, an antigen, an antibody, or a hapten.
92. The method of Claim 91, further comprising the step of binding the exposed functional group of at least one of the third set of molecules to a metal or a metal ion.
93. The method of Claim 92, wherein the exposed functional group is -SH, and the metal or metal ion is Au⁰, Ag⁰, or Ag⁺.

94. The method of Claim 92, wherein the exposed functional group is -COOH , and the metal or metal ion is Ag^0 or Ag^+ .
- 5 95. The method of Claim 58, wherein the molecules of the second set of molecules have a spacer and the molecules of the third set of molecules have first and the second spacers and the spacers are, independently, selected from the group consisting of an alkylene, a heteroalkylene, a heterocycloalkylene, an alkenylene, an alkynylene, an arylene, a heteroarylene, arylalkylene, and a heteroarylalkylene, wherein the alkylene, heteroalkylene, heterocycloalkylene, alkenylene, 10 alkynylene, arylene, heteroarylene, arylalkylene, or heteroarylalkylene may be substituted or unsubstituted.
- 15 96. The method of Claim 95, wherein the substituents for the alkylene, a heteroalkylene, a heterocycloalkylene, an alkenylene, an alkynylene, an arylene, a heteroarylene, an arylalkylene, and a heteroarylalkylene are selected from the group consisting of halogens and hydroxy.
- 20 97. The method of Claim 58, further comprising the steps of:
a) forming a pattern of one or more metal, metal oxide, or combinations thereof on a surface of a substrate using electron beam lithography;
b) contacting the surface with the first set of molecules, wherein each molecule of the first set of molecules has a reactive functional group that forms a bond between the metal or metal oxide and the molecules of the first set of molecules, thereby forming a master that comprises a first set of 25 molecules bound to the substrate to form a pattern.
98. The method of Claim 97, wherein the reactive functional group of at least one molecule from the first set of molecules is a thiol group or a protected thiol group, and at least a portion of the pattern formed is a metal selected from the group

consisting of gold, silver, copper, cadmium, zinc, palladium, platinum, mercury, lead, iron, chromium, manganese, tungsten, and any alloys thereof.

- 5 99. The method of Claim 97, wherein the reactive functional group of at least one molecule from the first set of molecules is a silane or a chlorosilane, and at least a portion of the pattern formed is a metal selected from the group consisting of doped and undoped silicon.
- 10 100. The method of Claim 97, wherein the reactive functional group of at least one molecule from the first set of molecules is a carboxylic acid, and at least a portion of the pattern formed is an oxide selected from the group consisting of silica, alumina, quartz, and glass.
- 15 101. The method of Claim 97, wherein the reactive functional group of at least one molecule from the first set of molecules is a nitrile or an isonitrile, and at least a portion of the pattern formed is a metal selected from the group consisting of platinum, palladium and alloys thereof.
- 20 102. The method of Claim 97, wherein the reactive functional group of at least one molecule from the first set of molecules is a hydroxamic acid, and at least a portion of the pattern formed is copper.
- 25 103. The method of Claim 58, wherein the step of providing the master comprises forming the master using dip pen nanolithography.
104. The method of Claim 58, wherein the step of providing the master comprises forming the master using replacement lithography, nanoshading or nanografting.

105. The method of Claim 58, wherein the step of providing the master comprises forming the master using nanopatterning.
106. The method of Claim 58, wherein at least one portion of the third substrate surface is free of the third set of molecules.
107. The method of Claim 106, further comprising the steps of:
- a) contacting the surface of the third substrate with a reactant selected to be chemically inert to the third set of molecules and to degrade at least the surface layer of the third substrate, thereby degrading the portion of the surface of the third substrate that is free of the third set of molecules; and
 - b) removing the third set of molecules to uncover a portion of the surface of the third substrate.
108. The method of Claim 107, wherein the reactant is a reactive ion etching compound.
109. The method of Claim 106, further comprising the steps of:
- a) depositing a material on the portion of the third substrate surface that is free of the third set of molecules; and
 - b) removing the third set of molecules to uncover a portion of the surface of the third substrate.
110. The method of Claim 109, wherein the deposited material is selected from the group consisting of semiconductors, dielectrics, metals, metal oxides, metal nitrides, metal carbides, and combinations thereof.

111. A composition, comprising:
- a) a master comprising a pattern of a first set of molecules bound to a first substrate; and
 - b) a complement image comprising a pattern of a second set of molecules bound to a second substrate via a reactive functional group on each molecule of the second set of molecules, wherein each molecule in the second set of molecules has a recognition component that binds to at least a portion of a molecule from the first set of molecule.
112. The composition of Claim 111, wherein each molecule of the second set of molecule further comprises one or more of the following components:
- a) an exposed functionality;
 - b) a covalent bond or a first spacer that links the reactive functional group to the recognition component; and
 - c) a covalent bond or a second spacer that links the exposed functionality to the recognition component.
113. The composition of Claim 112, wherein the second set of molecules comprises two or more different molecules.
114. The composition of Claim 113, wherein one or more molecules from the first set of molecules determines where each of the molecules from the second set of molecules binds.
115. The composition of Claim 114, wherein two or more molecules of the second set of molecules have different recognition components.

116. The composition of Claim 114, wherein two or more molecules of the second set of molecules have both different recognition components and different exposed functionalities.
- 5 117. The composition of Claim 114, wherein the two or more different molecules of the second set of molecules form a pattern on the second substrate that has a height profile that comprises two or more depths.
- 10 118. The composition of Claim 117, wherein at least one of the two or more different molecules comprises a first spacer, and another of the two or more different molecules either does not comprise a spacer or comprises a second spacer that has a different length from the first spacer.
- 15 119. The composition of Claim 112, wherein a lateral dimension of at least one feature of the complement image is less than 200 nm.
- 20 120. The composition of Claim 112, wherein the bonds formed between the first set of molecules and the second set of molecules are hydrogen bonds, ionic bonds, covalent bonds, van der Waals bonds, or a combination thereof.
- 25 121. The composition of Claim 120, wherein the bonds between the first set of molecules and the second set of molecules are broken.
122. The composition of Claim 120, wherein the bonds formed between the first set of molecules and the second set of molecules are hydrogen bonds.
123. The composition of Claim 112, wherein the reactive functional group on the second set of molecules is a thiol group or a protected thiol group, and the surface of the second substrate is gold, silver, copper, cadmium, zinc, palladium,

platinum, mercury, lead, iron, chromium, manganese, tungsten, or any alloys thereof.

- 5 124. The composition of Claim 112, wherein the reactive functional group on the second set of molecules is a silane or a chlorosilane, and the surface of the second substrate is doped or undoped silicon.
- 10 125. The composition of Claim 112, wherein the reactive functional group on the second set of molecules is a carboxylic acid, and the surface of the second substrate is an oxide.
- 15 126. The composition of Claim 125, wherein the oxide is silica, alumina, quartz, or glass.
- 15 127. The composition of Claim 112, wherein the reactive functional group on the second set of molecules is a nitrile or an isonitrile, and the surface of the second substrate is platinum, palladium or any alloy thereof.
- 20 128. The composition of Claim 112, wherein the reactive functional group on the second set of molecules is a hydroxamic acid, and the surface of the second substrate is copper.
- 25 129. The composition of Claim 112, wherein a component of each of the first set of molecules is a nucleic acid sequence and the recognition component of the second set of molecules is a nucleic acid sequence that has at least three consecutive bases that are complementary to at least three consecutive bases of at least one molecule from the first set of molecules.

130. The composition of Claim 129, wherein the bonds formed between the first set of molecules and the second set of molecules are hydrogen bonds.
- 5 131. The composition of Claim 130, wherein the second set of molecules comprises two or more different molecules.
- 10 132. The composition of Claim 131, wherein one or more molecules from the first set of molecules determines where each of the molecules from the second set of molecules binds.
133. The composition of Claim 132, wherein the first set of molecules comprises two or more molecules having different nucleic acid sequences.
- 15 134. The composition of Claim 132, wherein two or more molecules of the second set of molecules have different nucleic acid sequences.
- 20 135. The composition of Claim 134, wherein the nucleic acid sequence of the first and second sets of molecules are selected from the group consisting of DNA, RNA, modified nucleic acid sequences and combinations thereof.
- 25 136. The composition of Claim 135, wherein the hydrogen bonds between the first set of molecules and the second set of molecules are broken.
137. The composition of Claim 112, wherein a component of each of the first set of molecules is a peptide nucleic acid (PNA) sequence and the recognition component of the second set of molecules is a PNA sequence.
138. The composition of Claim 121, wherein the exposed functionality of each molecule of the second set of molecules is absent or is, independently, selected

from the group consisting of -OH, -CONH-, -CONHCO-, -NH₂, -NH-, -COOH, -COOR, -CSNH-, -NO₂⁻, -SO₂, -SH, -RCOR-, -RCSR-, -RSR, -ROR-, -PO₄⁻³, -OSO₃⁻², -SO₃⁻, -COO⁻, -SOO⁻, -RSOR-, -CONR₂, -(OCH₂CH₂)_nOH (where n=1-20, preferably 1-8), -CH₃, -PO₃H⁻, -2-imidazole, -N(CH₃)₂, -NR₂, -PO₃H₂, -CN, - (CF₂)_nCF₃ (where n=1-20, preferably 1-8), and an olefin,

wherein, R is hydrogen, a hydrocarbon, a halogenated hydrocarbon, a protein, an enzyme, a carbohydrates, a lectin, a hormone, a receptor, an antigen, an antibody, or a hapten.

10 139. The composition of Claim 138, further comprising a metal or a metal ion bound to the exposed functional group of at least one molecule from the second set of molecules.

140. The composition of Claim 139, wherein the exposed functional group is -SH, and
15 the metal or metal ion is Au⁰, Ag⁰, or Ag⁺.

141. The composition of Claim 139, wherein the exposed functional group is -COOH, and the metal or metal ion is Ag⁰ or Ag⁺.

20 142. The composition of Claim 112, wherein each molecule of the second set of molecules has a first spacer, a second spacer, or a first and the second spacer, and the spacers are, independently, selected from the group consisting of an alkylene, a heteroalkylene, a heterocycloalkylene, an alkenylene, an alkynylene, an arylene, a heteroarylene, arylalkylene, and a heteroarylalkylene, wherein the alkylene,
25 heteroalkylene, heterocycloalkylene, alkenylene, alkynylene, arylene, heteroarylene, arylalkylene, or heteroarylalkylene may be substituted or unsubstituted.

143. The composition of Claim 142, wherein the substituents for the alkylene, a heteroalkylene, an alkenylene, an alkynylene, an arylene, a heteroarylene, a heterocycloalkylene, an arylalkylene, and a heteroarylalkylene are selected from the group consisting of halogens and hydroxy.
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144. The composition of Claim 121, wherein at least one portion of the second substrate surface is free of the second set of molecules.
145. A composition, comprising:
- 10 a) a first pattern of a first set of molecules bound to a first substrate; and
- b) a second pattern of a second set of molecules bound to a second substrate via a reactive functional group on each molecule of the second set of molecules, wherein each molecule of the second set of molecules comprises a recognition component that binds to at least one molecule in
- 15 the first set of molecules, and wherein the second pattern is a complement image of the first pattern.
146. The composition of Claim 145, wherein each molecule of the second set of molecule further comprises one or more of the following components:
- 20 a) an exposed functionality;
- b) a covalent bond or a first spacer that links the reactive functional group to the recognition component; and
- c) a covalent bond or a second spacer that links the exposed functionality to the recognition component.
- 25
147. The composition of Claim 146, wherein the second set of molecules comprises two or more different molecules.

148. The composition of Claim 147, wherein one or more molecules from the first set of molecules determines where each of the molecules from the second set of molecules binds.
- 5 149. The composition of Claim 148, wherein two or more molecules of the second set of molecules have different recognition components.
150. The composition of Claim 148, wherein two or more molecules of the second set of molecules have both different recognition components and different exposed
10 functionalities.
151. The composition of Claim 148, wherein the two or more different molecules of the second set of molecules form a pattern on the second substrate that has a height profile that comprises two or more depths.
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152. The composition of Claim 151, wherein at least one of the two or more different molecules comprises a first spacer, and another of the two or more different molecules either does not comprise a spacer or comprises a second spacer that has a different length from the first spacer.
20
153. The composition of Claim 146, wherein a lateral dimension of at least one feature of the complement image is less than 200 nm.
154. The composition of Claim 146, wherein the reactive functional group of the
25 second set of molecules is a thiol group and the surface of the second substrate is gold, silver, copper, cadmium, zinc, palladium, platinum, mercury, lead, iron, chromium, manganese, tungsten, or any alloys thereof.

155. The composition of Claim 146, wherein the reactive functional group of the second set of molecules is a silane or a chlorosilane group and the surface of the second substrate is doped or undoped silicon.
- 5 156. The composition of Claim 146, wherein the reactive functional group of the second set of molecules is a carboxylic acid, and the surface of the second substrate is an oxide.
157. The composition of Claim 156, wherein the oxide is silica, alumina, quartz, or
10 glass.
158. The composition of Claim 146, wherein the reactive functional group of the second monolayer of complementary molecules is a nitrile or an isonitrile group, and the surface of the second substrate is platinum, palladium or any alloy
15 thereof.
159. The composition of Claim 146, wherein the reactive functional group of the second monolayer of complementary molecules is a hydroxamic acid, and the surface of the second substrate is copper.
20
160. The composition of Claim 146, wherein a component of each of the first set of molecules is a nucleic acid sequence and the recognition component of the second set of molecules is a nucleic acid sequence that has at least three consecutive bases that are complementary to at least three consecutive bases of at least one
25 molecule from the first set of molecules.
161. The composition of Claim 160, wherein the second set of molecules comprises two or more different molecules.

162. The composition of Claim 161, wherein one or more molecules from the first set of molecules determines where each of the molecules from the second set of molecules binds.
- 5 163. The composition of Claim 162, wherein the first set of molecules comprises two or more molecules having different nucleic acid sequences.
164. The composition of Claim 162, wherein two or more molecules of the second set of molecules have different nucleic acid sequences.
- 10 165. The composition of Claim 164, wherein the nucleic acid sequence of the first and second sets of molecules are selected from the group consisting of DNA, RNA, modified nucleic acid sequences and combinations thereof.
- 15 166. The composition of Claim 146, wherein a component of each of the first set of molecules is a peptide nucleic acid (PNA) sequence and the recognition component of the second set of molecules is a PNA sequence.
- 20 167. The composition of Claim 146, wherein the exposed functionality of each molecule of the second set of molecules is absent or is, independently, selected from the group consisting of -OH, -CONH-, -CONHCO-, -NH₂, -NH-, -COOH, -COOR, -CSNH-, -NO₂⁻, -SO₂, -SH, -RCOR-, -RCSR-, -RSR, -ROR-, -PO₄⁻³, -OSO₃⁻², -SO₃⁻, -COO⁻, -SOO⁻, -RSOR-, -CONR₂, -(OCH₂CH₂)_nOH (where n=1-20, preferably 1-8), -CH₃, -PO₃H⁻, -2-imidazole, -N(CH₃)₂, -NR₂, -PO₃H₂, -CN, -
 25 -(CF₂)_nCF₃ (where n=1-20, preferably 1-8), and an olefin,
 wherein, R is hydrogen, a hydrocarbon, a halogenated hydrocarbon, a protein, an enzyme, a carbohydrates, a lectin, a hormone, a receptor, an antigen, an antibody, or a hapten.

168. The composition of Claim 167, further comprising a metal or a metal ion bound to the exposed functional group of at least one molecule from the second set of molecules.
- 5 169. The composition of Claim 168, wherein the exposed functional group is –SH, and the metal or metal ion is Au⁰, Ag⁰, or Ag⁺.
170. The composition of Claim 168, wherein the exposed functional group is –COOH, and the metal or metal ion is Ag⁰ or Ag⁺.
- 10 171. The composition of Claim 146, wherein each molecule of the second set of molecules has a first spacer, a second spacer, or a first and the second spacer, and the spacers are, independently, selected from the group consisting of an alkylene, a heteroalkylene, a heterocycloalkylene, an alkenylene, an alkynylene, an arylene, 15 a heteroarylene, arylalkylene, and a heteroarylalkylene, wherein the alkylene, heteroalkylene, heterocycloalkylene, alkenylene, alkynylene, arylene, heteroarylene, arylalkylene, or heteroarylalkylene may be substituted or unsubstituted.
- 20 172. The composition of Claim 171, wherein the substituents for the alkylene, a heteroalkylene, a heterocycloalkylene, an alkenylene, an alkynylene, an arylene, a heteroarylene, an arylalkylene, and a heteroarylalkylene are selected from the group consisting of halogens and hydroxy.
- 25 173. The composition of Claim 146, wherein at least one portion of the second substrate surface is free of the second set of molecule.
174. The composition of Claim 146, wherein the portion of the second substrate that is free of the second set of molecules has been degraded.

175. The composition of Claim 173, wherein a material has been deposited on the portion of the second substrate that is free of the second set of molecules.
- 5 176. The composition of Claim 175, wherein the deposited material is selected from the group consisting of semiconductors, dielectrics, metals, metal oxides, metal nitrides, metal carbides, and combinations thereof.
177. A composition, comprising:
- 10 a) a first pattern of a first set of molecules bound to a first substrate; and
b) a second substrate, wherein the second substrate comprises a degraded portion and an undegraded portion and is a complement image of the first pattern.
- 15 178. The composition of Claim 177, wherein the complement image is formed by a method comprising the steps of:
- a) forming a second pattern of a second set of molecules on the second substrate, wherein the second pattern is a complement image of the first pattern, and wherein at least one portion of the second substrate surface is
20 free of the second set of molecules;
- b) degrading the portion of the second substrate that is free of the second set of molecules; and
- c) removing the second set of molecules from the second substrate, thereby exposing the surface of the second substrate.
- 25 179. A composition, comprising:
- a) a first pattern of a first set of molecules bound to a first substrate; and

- b) a second substrate having a patterned layer of a material deposited thereon, wherein the patterned layer of deposited material on the second substrate is a complement image of the first pattern.
- 5 180. The composition of Claim 179, wherein the complement image is formed on the second substrate by a method comprising the steps of:
- a) forming a second pattern of a second set of molecules on the second substrate, wherein the second pattern is a complement image of the first pattern, and wherein at least one portion of the second substrate surface is
10 free of the second set of molecules;
 - b) depositing a material on the portion of the second substrate that is free of the second set of molecules; and
 - c) removing the second set of molecules from the second substrate, thereby exposing the surface of the second substrate.
- 15
181. The composition of Claim 179, wherein the deposited material is selected from the group consisting of semiconductors, dielectrics, metals, metal oxides, metal nitrides, metal carbides, and combinations thereof.
- 20 182. A kit for printing a molecular pattern on a substrate, comprising:
- a) a master comprising a pattern of a first set of molecules bound to a substrate; and
 - b) a second set of molecules, wherein the second set of molecules comprise:
 - i) a reactive functional group; and
25 ii) a recognition component that binds to the first set of molecules.
183. The kit of Claim 182, wherein each molecule of the second set of molecules further comprises one or more of the following components:
- a) an exposed functionality;

- b) a covalent bond or a first spacer that links the reactive functional group to the recognition component; and
- c) a covalent bond or a second spacer that links the exposed functionality to the recognition component.

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184. The kit of Claim 183, wherein the second set of molecules comprises two or more different molecules.

185. The kit of Claim 184, wherein one or more molecules from the first set of molecules determines where each of the molecules from the second set of molecules binds.

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186. The kit of Claim 185, wherein two or more molecules of the second set of molecules have different recognition components.

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187. The kit of Claim 185, wherein two or more molecules of the second set of molecules have both different recognition components and different exposed functionalities.

20 188. The kit of Claim 187, wherein at least one of the two or more different molecules comprises a first spacer, and another of the two or more different molecules either does not comprise a spacer or comprises a second spacer that has a different length from the first spacer.

25 189. The kit of Claim 183, wherein a lateral dimension of at least one feature of the master is less than 200 nm.

190. The kit of Claim 183, wherein the recognition component of each molecule of the second set of molecules can bind to at least one molecule of the first set of

molecules via hydrogen bonds, ionic bonds, covalent bonds, van der Waals bonds, or a combination thereof.

5 191. The kit of Claim 190, wherein the recognition component of each molecule of the second set of molecules can bind to at least one molecule of the first set of molecules via hydrogen bonds.

10 192. The kit of Claim 191, further comprising a solution having a high ionic strength that can break the bonds between the first set of molecules and the second set of molecules.

193. The kit of Claim 183, further comprising a second substrate that binds to the reactive functional group of the second set of molecules.

15 194. The kit of Claim 193, wherein the reactive functional group on the second set of molecules is a thiol group or a protected thiol group and the second substrate has a surface that is gold, silver, copper, cadmium, zinc, palladium, platinum, mercury, lead, iron, chromium, manganese, tungsten, or any alloys thereof.

20 195. The kit of Claim 193, wherein the reactive functional group on the second set of molecules is a silane or a chlorosilane, and the surface of the second substrate is doped or undoped silicon.

25 196. The kit of Claim 193, wherein the reactive functional group on the second set of molecules is a carboxylic acid, and the surface of the second substrate is an oxide.

197. The kit of Claim 196, wherein the oxide is silica, alumina, quartz, or glass.

198. The kit of Claim 193, wherein the reactive functional group on the second set of molecules is a nitrile or an isonitrile, and the surface of the second substrate is platinum, palladium or any alloy thereof.
- 5 199. The kit of Claim 193, wherein the reactive functional group on the second set of molecules is a hydroxamic acid, and the surface of the second substrate is copper.
200. The kit of Claim 193, wherein a component of each of the first set of molecules is a nucleic acid sequence and the recognition component of the second set of
10 molecules is a nucleic acid sequence that has at least three consecutive bases that are complementary to at least three consecutive bases of at least one molecule from the first set of molecules.
201. The kit of Claim 200, wherein the second set of molecules comprises two or more
15 different molecules.
202. The kit of Claim 201, wherein one or more molecules from the first set of molecules determines where each of the molecules from the second set of molecules binds.
20
203. The kit of Claim 202, wherein the first set of molecules comprises two or more molecules having different nucleic acid sequences.
204. The kit of Claim 202, wherein two or more molecules of the second set of
25 molecules have different nucleic acid sequences.
205. The kit of Claim 200, further comprising a solution having an enzyme that can break the bonds between the first set of molecules and the second set of molecules.

206. The kit of Claim 200, further comprising a solution having a high ionic strength for breaking the bonds between the first set of molecules and the second set of molecules.
- 5
207. The kit of Claim 200, wherein the nucleic acid sequence of the first and second sets of molecules are selected from the group consisting of DNA, RNA, modified nucleic acid sequences and combinations thereof.
- 10
208. The kit of Claim 183, wherein a component of each of the first set of molecules is a peptide nucleic acid (PNA) sequence and the recognition component of the second set of molecules is a PNA sequence.
- 15
209. The kit of Claim 183, wherein the exposed functionality of each molecule of the second set of molecules is absent or is, independently, selected from the group consisting of -OH, -CONH-, -CONHCO-, -NH₂, -NH-, -COOH, -COOR, -CSNH-, -NO₂⁻, -SO₂, -SH, -RCOR-, -RCSR-, -RSR, -ROR-, -PO₄⁻³, -OSO₃⁻², -SO₃⁻, -COO⁻, -SOO⁻, -RSOR-, -CONR₂, -(OCH₂CH₂)_nOH (where n=1-20, preferably 1-8), -CH₃, -PO₃H⁻, -2-imidazole, -N(CH₃)₂, -NR₂, -PO₃H₂, -CN, -CF₂)_nCF₃ (where n=1-20, preferably 1-8), and an olefin,
- 20
- wherein, R is hydrogen, a hydrocarbon, a halogenated hydrocarbon, a protein, an enzyme, a carbohydrates, a lectin, a hormone, a receptor, an antigen, an antibody, or a hapten.
- 25
210. The kit of Claim 209, further comprising a metal or a metal ion that can bind to the exposed functional group of at least one of the second set of molecules.
211. The kit of Claim 210, wherein the exposed functional group is -SH, and the metal or metal ion is Au⁰, Ag⁰, or Ag⁺.

212. The kit of Claim 210, wherein the exposed functional group is -COOH , and the metal or metal ion is Ag^0 or Ag^+ .
- 5 213. The kit of Claim 183, wherein each molecule of the second set of molecules has a first spacer, a second spacer, or a first and the second spacer, and the spacers are, independently, selected from the group consisting of an alkylene, a heteroalkylene, a heterocycloalkylene, an alkenylene, an alkynylene, an arylene, a heteroarylene, arylalkylene, and a heteroarylalkylene, wherein the alkylene, heteroalkylene, heterocycloalkylene, alkenylene, alkynylene, arylene, heteroarylene, arylalkylene, or heteroarylalkylene may be substituted or unsubstituted.
- 10 214. The kit of Claim 213, wherein the substituents for the alkylene, a heteroalkylene, a heterocycloalkylene, an alkenylene, an alkynylene, an arylene, a heteroarylene, an arylalkylene, and a heteroarylalkylene are selected from the group consisting of halogens and hydroxy.
- 15 215. A molecular printer for generating a complement image of a master having a first set of molecules bound to a surface of a first substrate, comprising:
- 20 a) a device for delivering a solution of a second set of molecules to the surface of the master, wherein the second set of molecules comprises:
- i) a reactive functional group; and
- ii) a recognition component that binds to the first set of molecules;
- 25 and
- b) a device for contacting the second set of molecules with a second substrate.

216. The molecular printer of Claim 215, wherein each molecule of the second set of molecules further comprises one or more of the following components:
- a) an exposed functionality;
 - b) a covalent bond or a first spacer that links the reactive functional group to the recognition component; and
 - c) a covalent bond or a second spacer that links the exposed functionality to the recognition component.
217. The molecular printer of Claim 216, further comprising a device for breaking the bonds between the first set of molecules and the second set of molecules.
218. The molecular printer of Claim 217, wherein the device for breaking the bonds between the first set of molecules and the second set of molecules is a heating element.
219. The molecular printer of Claim 217, wherein the device for breaking the bonds between the first set of molecules and the second set of molecules is a device that delivers a solution having a high ionic strength to the bound first and second set of molecules.
220. The molecular printer of Claim 217, wherein the device for contacting the second set of molecules with a second substrate is a clamp that clamps the master to the second substrate.
221. The molecular printer of Claim 217, further comprising a device for separating the second substrate from the master after the bonds between the first set of molecules and the second set of molecules have been broken.

222. The molecular printer of Claim 221, wherein the solution of the second set of molecules comprises two or more different molecules.
- 5 223. The molecular printer of Claim 222, wherein one or more molecules from the first set of molecules determines where each of the molecules from the second set of molecules binds.
224. The molecular printer of Claim 223, wherein two or more molecules of the second set of molecules have different recognition components.
- 10 225. The molecular printer of Claim 223, wherein two or more molecules of the second set of molecules have both different recognition components and different exposed functionalities.
- 15 226. The molecular printer of Claim 224, wherein at least one of the two or more different molecules comprises a first spacer, and another of the two or more different molecules either does not comprise a spacer or comprises a second spacer that has a different length from the first spacer.
- 20 227. The molecular printer of Claim 221, wherein a lateral dimension of at least one feature of the master is less than 200 nm.
228. The molecular printer of Claim 221, wherein the recognition component of each molecule of the second set of molecules can bind to at least one molecule of the first set of molecules via hydrogen bonds, ionic bonds, covalent bonds, van der
- 25 Waals bonds, or a combination thereof.

229. The molecular printer of Claim 228, wherein the recognition component of each molecule of the second set of molecules can bind to at least one molecule of the first set of molecules via hydrogen bonds.
- 5 230. The molecular printer of Claim 221, wherein the reactive functional group on the second set of molecules is a thiol group or a protected thiol group and the second substrate has a surface that is gold, silver, copper, cadmium, zinc, palladium, platinum, mercury, lead, iron, chromium, manganese, tungsten, or any alloys thereof.
- 10 231. The molecular printer of Claim 221, wherein the reactive functional group on the second set of molecules is a silane or a chlorosilane, and the surface of the second substrate is doped or undoped silicon.
- 15 232. The molecular printer of Claim 221, wherein the reactive functional group on the second set of molecules is a carboxylic acid, and the surface of the second substrate is an oxide.
- 20 233. The molecular printer of Claim 232, wherein the oxide is silica, alumina, quartz, or glass.
234. The molecular printer of Claim 221, wherein the reactive functional group on the second set of molecules is a nitrile or an isonitrile, and the surface of the second substrate is platinum, palladium or any alloy thereof.
- 25 235. The molecular printer of Claim 221, wherein the reactive functional group on the second set of molecules is a hydroxamic acid, and the surface of the second substrate is copper.

236. The molecular printer of Claim 221, wherein a component of each of the first set of molecules is a nucleic acid sequence and the recognition component of the second set of molecules is a nucleic acid sequence that has at least three consecutive bases that are complementary to at least three consecutive bases of at least one molecule from the first set of molecules.
237. The molecular printer of Claim 236, wherein the solution of the second set of molecules comprises two or more different molecules.
238. The molecular printer of Claim 237, wherein one or more molecules from the first set of molecules determines where each of the molecules from the second set of molecules binds.
239. The molecular printer of Claim 238, wherein the first set of molecules comprises two or more molecules having different nucleic acid sequences.
240. The molecular printer of Claim 238, wherein two or more molecules of the second set of molecules have different nucleic acid sequences.
241. The molecular printer of Claim 236, wherein the nucleic acid sequence of the first and second sets of molecules are selected from the group consisting of DNA, RNA, modified nucleic acid sequences and combinations thereof.
242. The molecular printer of Claim 221, wherein a component of each of the first set of molecules is a peptide nucleic acid (PNA) sequence and the recognition component of the second set of molecules is a PNA sequence.
243. The molecular printer of Claim 221, wherein the exposed functionality of each molecule of the second set of molecules is absent or is, independently, selected

from the group consisting of -OH, -CONH-, -CONHCO-, -NH₂, -NH-, -COOH, -COOR, -CSNH-, -NO₂⁻, -SO₂, -SH, -RCOR-, -RCSR-, -RSR, -ROR-, -PO₄⁻³, -OSO₃⁻², -SO₃⁻, -COO⁻, -SOO⁻, -RSOR-, -CONR₂, -(OCH₂CH₂)_nOH (where n=1-20, preferably 1-8), -CH₃, -PO₃H⁻, -2-imidazole, -N(CH₃)₂, -NR₂, -PO₃H₂, -CN, -
5 -(CF₂)_nCF₃ (where n=1-20, preferably 1-8), and an olefin,

wherein, R is hydrogen, a hydrocarbon, a halogenated hydrocarbon, a protein, an enzyme, a carbohydrates, a lectin, a hormone, a receptor, an antigen, an antibody, or a hapten.

10 244. The molecular printer of Claim 221, wherein each molecule of the second set of molecules has a first spacer, a second spacer, or a first and the second spacer, and the spacers are, independently, selected from the group consisting of an alkylene, a heteroalkylene, a heterocycloalkylene, an alkenylene, an alkynylene, an arylene, a heteroarylene, arylalkylene, and a heteroarylalkylene, wherein the alkylene,
15 heteroalkylene, heterocycloalkylene, alkenylene, alkynylene, arylene, heteroarylene, arylalkylene, or heteroarylalkylene may be substituted or unsubstituted.

20 245. The molecular printer of Claim 244, wherein the substituents for the alkylene, a heteroalkylene, a heterocycloalkylene, an alkenylene, an alkynylene, an arylene, a heteroarylene, an arylalkylene, and a heteroarylalkylene are selected from the group consisting of halogens and hydroxy.